is capable of being formed to extend into the etched apertures and substantially through the dielectric film approaching the conductors on the first surface. As shown in FIG. **5***e,* the first surface **508** of the film is positioned on and supported by a solid die plate **520** in a press. A hydraulic or pneumatic force, represented by arrows **521**, is applied to the second surface, whereby the continuous copper film **504** on the second surface is stretch-formed to approximately conform to the aperture sidewalls, and to approach the plane of the first copper surface **508** of the dielectric **505**.

In FIG. **6***a,* a copper plated layer **603** is initiated from the formed continuous copper film **504**. Selective plating is accomplished in the following manner; the continuous copper film **504** on the second surface of the dielectric is brought into contact with the cathode of a copper plating bath, and current applied from a rectifier to the cathode and the anode. In FIG. **6***b* and **6***c,* copper proceeds to plate from the top side of the cathode film until the plated copper meshes with the cusps **518** of the conductor layer on the first surface of the dielectric and makes a continuous electrical circuit. In FIG. **6***c,* the layer of plated copper forms a solid mass between the copper film **504** lining the aperture and the conductor on the first surface, thereby providing a robust conductive via structure. Plating occurs only from a continuous cathode, and at the point when contact between conductors on the first and second surface is continuous, plating will begin to occur on all surfaces.

The preferred embodiment of the current invention provides an intermediate structure for a flex film, having a plurality of conductive vias corresponding to sites for interconnecting the conductors on the surfaces on a flex circuit, wherein the vias **601** have an indention for positioning solder balls, as shown in FIG. **6***c.*

A second embodiment of an intermediate structure for a flex circuit having conductive vias including a continuous copper film lining attached to the second surface of a dielectric wherein the lining has been press fit into the apertures, and including copper plating providing contact between the copper conductors on the first surface and the via lining copper, further includes partially or fully filling the indented vias with copper plating. The via structure shown in FIG. **3** depicts the vias **302**, formed by the same steps as those in the preferred embodiment and shown in in FIGS. **5** and **6**, but having the indentation partially filled with plated copper **307**. The cavity depth of the indentation is controlled by the amount of additional copper plating **307**, and provides a means to select the cavity depth as needed by the solder ball diameter.

In a related embodiment, vias are fully plated with copper between the conductor surfaces. As shown in FIG. **7***a,* a commercially available flexible dielectric film **705** having a layer of copper **702** and **704** on the major surfaces, is laminated with photoresist **710** on both surfaces. A photopattern corresponding to via sites **701** in a flex circuit is aligned, exposed and developed on each surface using known technology. The exposed copper is etched simultaneously in FIG. **7***b* using a commercially available copper etch solution, such as an ammoniacal etchant. In the next step, the photoresist is removed and the polymer etched from both surfaces using a caustic etchant and the copper as a mask. As with the previous embodiment, and as shown in FIG. **5***d,* the copper is undercut providing cusps **518** of copper film overhanging the apertures.

The second surface **702** of the film is brought into intimate contact with the cathode **720** of a copper plating bath, and current applied by a rectifier to the cathode and anode, whereby copper **703** will begin to plate from the cathode and to fill the apertures as shown in FIGS. **7***c* through **7***e.* Copper plating proceeds from the single cathode surface, thereby avoiding entrapment of voids and air pockets as is typical of plating which occurs from two surfaces. Current is applied and plating is continued until the plated copper electrically contacts the copper conductors **704** on the first surface of the film. The plated via comprises a solid copper core in contact with the copper film on both surfaces of the dielectric film.

Alternately apertures can be formed by mechanical punching and the dielectric etched to provide a clean dielectric surface suitable for plating, and having copper cusps overhanging the apertures. Plating will be accomplished in the same manner as shown in FIGS. **7***c* through **7***e.*

Each of the disclosed methods provides a novel, intermediate structure for a flex circuit wherein a conductive layer on the first surface of a dielectric film is connected to a conductor on the second surface by a plurality of solid copper conductive vias arrayed in a pattern corresponding to that of flex circuit. Known technology is used to complete the circuit by patterning and etching a series of traces in the copper layer on the first surface and a plurality of solder ball contact pads on the second surface of the film. The traces on the first surface provide electrical interconnection from a plurality of lands for solder balls or wire bonds connections from an integrated circuit chip to either a common interconnection between some chip terminals, such as power or ground buses, or the traces terminate at the conductive vias in the intermediate structure. Metallization on the circuits is finished by a layer of nickel and of gold disposed over the exposed copper, using technology known in the art.

Processes and materials required for patterning the circuits and solder ball pads are not unlike those typically used for flex circuit formation except that alignment is to preformed conductive vias, rather than patterning conductors on two surfaces, attempting to align the two patterns and connect the vias at the precise locations.

Mechanization for fabricating a flexible circuit for use as an integrated circuit area array package substrate is well adapted to reel to reel film transport. The appropriate film width will be selected for single or multiple packages, as required by the end user's transport equipment. Sprocket holes are located along the edges of the film to mate with those of the transport mechanism. Continuous processing to form an intermediate structure for a flex circuit includes the following steps: alignment of a mask to a dielectric film having a layer of copper on both major surfaces and laminated with photoresist, exposure, development of the resist, and etching the copper and dielectric layers. Continuous processing further includes plating copper from a single surface by means of a drum cathode contact with the conductor surface; such continuous processing is well suited to reel to reel automation. Sprocket driven reel to reel mechanization facilitates photolithography, etching and plating processes as required for the flex circuit production.

While the invention has been described in connection with preferred embodiments, it is not intended to limit the scope to a particular form set forth, but on the contrary, it is intended to cover alternatives, modifications and equivalents as may be included within the spirit of the invention and the scope of the invention as defined by the appended claims.

What is claimed is:

1. A double sided electrical interconnection flexible circuit to enable interconnecting an integrated circuit chip to an external circuit including:

a base dielectric film having a plurality of vias extending from the first major surface to the second major surface of said dielectric,